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BY-PRODUCTS FROM CITRUS FRUITS

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CONTENTS.

	Page.
Uses for the juice	1
Bottled grapefruit juice	1
Orange vinegar	4
Citric acid	7
Candied citrus peel	8
Candied grapefruit peel	8
Candied orange peel	9
Marmalades	10
Clear orange marmalade	10
Orange marmalade (three-day method)	11
Marmalades—Continued.	
Sweet orange or grapefruit marmalade	11
Bitter orange marmalade	11
Jellies	12
Bitter orange jelly	12
Grapefruit jelly	12
Mint and orange pectin jelly	12
Orange butter	13

THE Bureau of Chemistry has investigated methods for utilizing bruised, undersized, or oversized oranges, grapefruit, and lemons, great numbers of which are allowed to go to waste each year. It has been found possible to prepare excellent juice, jam, marmalade, and jelly from such fruit, which can then be disposed of to the profit of the grower. A ready market awaits these products when they have been carefully prepared according to the following directions, which have been tested in the laboratory.

USES FOR THE JUICE.

Grapefruit juice is a favorite among the refreshing fruit juices now on the market. Since vinegar made from oranges is quite as satisfactory as that prepared from apples, orange vinegar might well be substituted for apple vinegar in regions where many cull oranges would otherwise be a total loss. Citrate of lime, an article of importance commercially, can be made from cull lemons or limes by the ambitious grower who is able and willing to go to some trouble and expense to install the requisite equipment.

BOTTLED GRAPEFRUIT JUICE.

APPARATUS.

The press.—A platform press, like most cider presses, is best, as this type does not grind or macerate the fruit. A clearer juice is obtained and less difficulty in its clarification is encountered when cloth containers for the fruit are used.

The strainer.—Although it is not always necessary to use a strainer, if one is employed it should be made of copper or bronze gauze, never of iron. For best results, silver plating will not prove too expensive. One ounce to each square foot of surface, well put on, will last for several years.

The pasteurizer.—The apparatus used in the laboratory experiments consisted of an 8-inch coil of ¼-inch silver tubing, 2 inches across the coils, and ¼ inch between the folds, set in a small tinplate boiler, and projecting through the sides at the top and bottom. It was thus possible to fasten it to the juice reservoir by a rubber connection and also to carry the finished product to the receptacles in the same manner. In this way the bottom of the can is left clear for the application of the heat. This apparatus, of course, is inadequate for any but small lots of juice, as its capacity is only a little over 2 gallons an hour. It may be readily enlarged, however, by increasing the width of the tube, thus permitting a greater flow of juice. It is also possible to increase the rapidity of the flow by lengthening the coil and using a tight reservoir and pressure. Commercial apparatus constructed on the same principle can be obtained from dealers in cider and vinegar supplies. The flash pasteurizer for milk may also be employed for this work. A type built on the plan of an ice cream freezer has been successfully operated in the laboratory. Instead of the usual stirring apparatus, a solid wing dasher, revolving at the rate of 300 revolutions per minute, was used. The body of the apparatus was surrounded on the sides and bottom by a steam or hot-water jacket.

Containers.—Carboys having a capacity of 5 gallons are used to receive the juice from the pasteurizer, and final bottling is generally done in ordinary crown-cap bottles of desirable size.

PROCEDURE.

Preparation of fruit.—Wash the fruit and cut it into halves or quarters, depending on the size of the press to be used. It is well to avoid very small pieces. Do not chop or shred, for the more the juice comes into contact with the peel, the more bitter will be the flavor of the product.

Pressing out the juice.—Place the quartered or halved fruit in the press. Apply the pressure gradually, as better yields of juice are thus obtained, to say nothing of the saving on the filter cloth. Depending upon the efficiency of the pressing outfit and the character of the fruit, from 70 to 100 gallons of juice should be obtained from a ton of grapefruit.

Straining the juice.—Now strain the juice through cloth or a copper or bronze gauze strainer. The strainer should be cleaned with hot water immediately after use.

Pasteurizing the juice.—Subject the juice to a preliminary pasteurization at 170° to 185° F. (75° to 85° C.) immediately. The quality of the product depends largely upon pasteurizing conditions. When the process takes place in bottles, part of the juice is sure to be overheated. A pasteurizer which instantly brings the juice to the desired temperature with the minimum overheating, therefore, should be used. Best results are obtained by heating a thin film of juice while it is in motion. Fill the boiler with water and bring it to boiling. Place the juice reservoir above the level of the apparatus and siphon this juice into the lower end of the tube. Lead the juice directly from the upper end into recently sterilized, hot 5-gallon carboys, which are filled in to the necks, leaving only sufficient room to force in the corks. Before putting in the corks, boil them for several minutes in water. The juice should leave the apparatus at from 170° to 185° F., the flow being so regulated as to maintain this temperature. When the milk type of pasteurizer is used, pass boiling water or steam through the steam jacket and feed a small stream of juice into the receiver. Thus a temperature not to exceed 180° F. can be secured and a flow up to 25 gallons an hour maintained.

Settling out the sediment.—As soon as the 5-gallon bottles have been tightly corked, place them in cool storage, not to exceed 50° F., and permit them to remain there until the sediment has settled out, which usually requires from 60 to 90 days. No harm ensues, however, if the storage lasts longer; in fact, final bottling is usually delayed as much as possible.

Clarifying the juice.—When ready for bottling, carefully decant or siphon the clear liquid from the sediment in the carboys. While the juice can be bottled without filtering, better results have been secured in the laboratory by treating it with from 1 to 2 pounds of kieselguhr (infusorial earth) to each 100 gallons and filtering through cloth. Treat the sediment in the same way, using 5 to 10 pounds of kieselguhr per 100 gallons. The ordinary rack and plate filter press, with low pressures, can be used for filtering. Where iron presses only are available, they should be repeatedly varnished with a waterproof, heat-resisting varnish. Do not buy kieselguhr until an actual test has been made with it, as some grades are worthless for this clarification. A large-grained material is best and before being used it must be repeatedly washed with hot water until tasteless.

Sweetening the juice.—When the acidity exceeds 1 per cent, it is best to sweeten the juice before final bottling, and to finish each lot by bringing it to a standard specific gravity or acid-solids ratio by the addition of sugar. The specific gravity can readily be taken with a Brix spindle, which gives the percentage of solids in the juice. California grapefruit juice gives most satisfaction when sweetened to contain from 17 to 20 per cent of solids.

Blending the juice.—A blend with loganberry juice is somewhat more popular than the straight grapefruit juice. The mixture consists of 15 to 20 per cent of loganberry juice with 80 to 85 per cent of grapefruit juice. The loganberry juice is added before the clarification with kieselguhr. This product has a clear red color and a fine flavor.

Bottling.—For final bottling, repeat the sterilization process already described, and run the hot juice into the final containers, recently sterilized and still hot. Cap them at once, and allow them to cool slowly. Do not use caps covered with paraffin, as the hot liquid melts this material, which flakes off, giving the juice the appearance of starting a second sedimentation.

Storing.—Ordinarily, in common storage, this juice stays clear for months, without losing its natural rich yellow color.

ORANGE VINEGAR (ROLLER PROCESS).

APPARATUS.

The press.—An ordinary cider press or a kitchen fruit press may be used.

The generator.—The generator may be made from an ordinary vinegar or whisky barrel. The hoops are so loosened that one head can be removed from the barrel, after which a small rack is fitted in to form a compartment throughout the entire length of the barrel, about 6 inches below the bung, to be filled later with beechwood shavings or corncobs. To build this rack quickly, set ½ inch apart in grooved end pieces slats which are 3 inches wide and ½ inch thick. Support the rack at each end by a 2 by 4 inch piece cut in lengths to make the rack fit in at least 6 inches below the bung. The 2 by 4's usually are joined at the bottom by a cross piece 1 by 2 inches. Set the rack in place, fill the compartment with cobs or shavings, rehead the barrel, and bore in each end three 1-inch holes, slanting downward, opening just beneath the bottom of the rack which holds the shavings or cobs. Use grooves or dowels, or, if more convenient, hardwood pegs, to fasten the rack to the 2 by 4's and hold it together. Nails made from iron or any other metal should not enter into its construction. The capacity of such a generator is from 30 to 40 gallons of vinegar.

PROCEDURE.

Preparation of the juice.—Press the juice from the oranges and strain out any large particles of fiber or peel that may be found. Add 1 pint of brewers' yeast or 6 cakes of compressed yeast which have been softened in orange juice. Now set the juice aside in a barrel, keg, or tub for several days, keeping it loosely covered with a cloth as a protection against flies. It is best to keep it at a temperature of 85° F. As soon as fermentation ceases, usually from 3 to 5 days later, according to the temperature, strain the juice again.

Generating the vinegar.—When the generator is to be used for the first time or when it has been standing idle for some time, scald it thoroughly before using it. This can be done by blowing steam into the bung, or by merely giving it a good washing with hot water. After the water has been thoroughly drained out, add about a quart of good vinegar (cider, malt, or orange) which has not been pasteurized. Allow the vinegar to flow over the shavings and the inside of the barrel. Now add the fermented orange juice through the bung, close the bung tightly with its wooden stopper, and plug the holes in the ends of the barrel with ordinary raw cotton. Several times, if possible, but at least once each day, turn the barrel over so that the bung is at the bottom, and shake three or four times to bring the juice in the barrel thoroughly in contact with the shavings or cobs. Before inverting the barrel, replace the cotton plugs with wooden ones. After rolling the barrel back into its original position, remove the wooden pegs and reinsert the cotton plugs. An excellent vinegar is produced by keeping up this treatment daily, at a temperature above 80° F., for from 60 to 90 days.

Bottling the vinegar.—When the material is sufficiently acid, remove it from the barrel, place it in clean hot glass bottles, and cork tightly.

Sterilizing the vinegar.—The vinegar may be sterilized readily by heating the filled bottles in boiling water for from 15 to 20 minutes. This treatment prevents any deterioration in quality and appearance which might otherwise occur during storage.

Clarifying the vinegar.—Unless brilliantly clear when taken from the barrel, vinegar should be filtered through infusorial earth before being bottled and sterilized.

ORANGE VINEGAR (RAPID GENERATOR PROCESS).

APPARATUS.

A small generator, having a capacity of about 50 gallons per day, consists of a vat 6 feet high by 3 feet in diameter (Fig. 1). About 6 inches from the top and bottom perforated disks are fitted tightly into the sides. The space between these two disks is filled with beechwood shavings. Just over the top disk is an automatic distributor which dumps a certain amount of liquid, first on one side of the apparatus, then on the other, thus evenly distributing the liquid over the perforated disk, through which it runs upon the beechwood shavings. The vat is fitted with a removable head, through which the liquid vinegar material is carried by means of a small pipe line.

A series of 1-inch holes, slanting downward, are bored through the sides of the tank just below the lower disk. These are fitted with tight wooden pegs, which in turn have small holes drilled through them. Small solid pegs to plug the holes in the larger pegs should be provided. No iron or other metallic substance should be used in the construction of the apparatus in such a way that it will come in contact with the liquid. At the very bottom of the vat is a spigot for drawing off the vinegar.

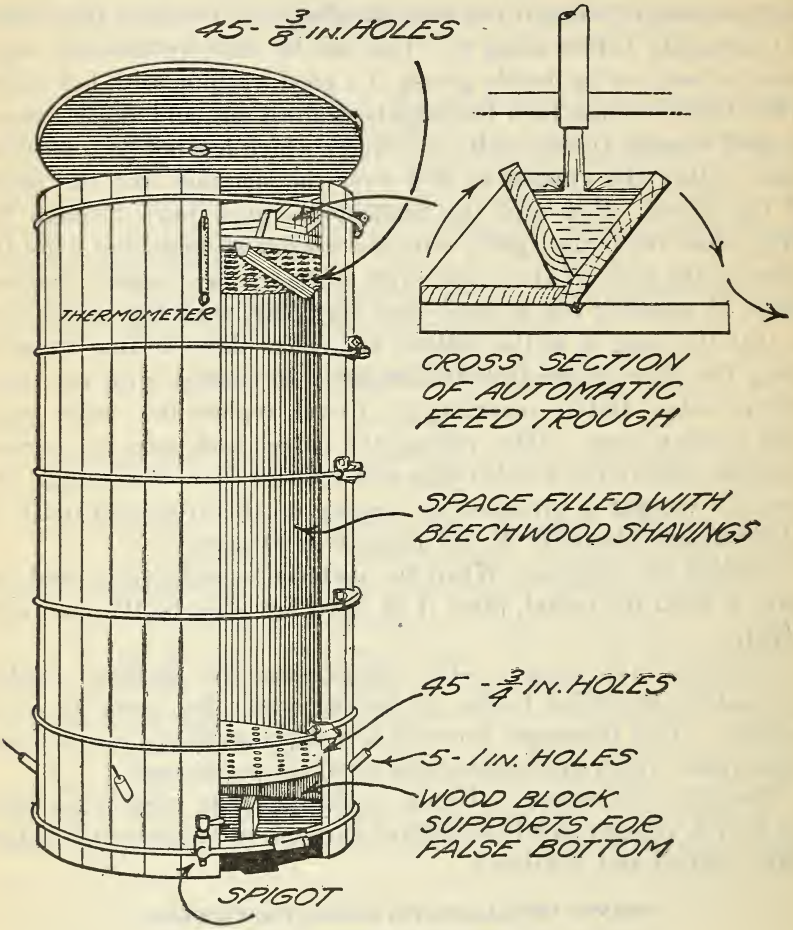
45-$\frac{3}{8}$ IN. HOLES
THERMOMETER
CROSS SECTION OF AUTOMATIC FEED TROUGH
SPACE FILLED WITH BEECHWOOD SHAVINGS
45-$\frac{3}{4}$ IN. HOLES
5-1 IN. HOLES
WOOD BLOCK SUPPORTS FOR FALSE BOTTOM
SPIGOT

FIG. 1.—Orange vinegar generator.

PROCEDURE.

Preparation of the juice.—The juice is prepared as in the barrel process (p. 4). The alcoholic fermentation is also identical with that in the barrel method. A centrifugal clarifier can be used to advantage in clearing up the juice before running it into the generator, but it is not necessary.

Generating the vinegar.—Place the juice in its reservoir above the generator. Before starting the flow, however, seed down the generator with cider, malt, or orange vinegar, taking care not to use material which has been pasteurized. Pass through the generator a quantity sufficient to saturate the shavings thoroughly, and draw it off at the bottom to use again. Leave all the air holes open while doing this. When the shavings are well impregnated with vinegar, start the flow of the fermented juice, allowing a small stream to run into the distributor. Watch closely the temperature indicated on the thermometer and keep it as nearly as possible at 86° F. This is done by governing the flow of air through the ventilating holes beneath the lower perforated disk, removing the pegs when the temperature drops below 86° and replacing them, one at a time, when it rises above that point. At times it is necessary to close not only the main holes, but also those in the large pegs. If this does not stop the rise in temperature, increase the flow of fermented juice. When pegs are removed, close the holes with loose wads of cotton to keep out flies. If acetification is not complete, mix the product back with the fermented juice. When mixing back has taken place, the product is practically always fully converted. Many producers prefer to leave at least one-half of 1 per cent of alcohol in their vinegar.

Bottling the vinegar.—When the product is to be sold in bottles, filter and pasteurize it before bottling. This makes a clearer, better-looking vinegar, and one that will not become cloudy after the bottle is opened.

Any cider or vinegar supply house where supplies are purchased will furnish manuals describing in detail the operation of their apparatus, and also methods for testing the finished product.

CITRIC ACID.

Although it is impossible to formulate a general plan for a citric acid plant without first going over the ground, the following outline shows the essential steps in the process. The Laboratory of Fruit and Vegetable Chemistry, 148 South Anderson Street, Los Angeles, Calif., will gladly give assistance to anyone who seriously contemplates starting a plant of this kind.

PROCEDURE.

Preparation of citrate of lime.—Boil the juice expressed from lemons or limes with large-grained kieselguhr (infusorial earth), in the proportion of from 5 to 10 pounds of the earth to 100 gallons of juice. Separate the kieselguhr and coagulated material from the juice by filtration, bring the juice to boiling again, and neutralize it with ordinary lime or very pure ground limestone. Filter the precipitated calcium citrate, and wash it once or twice with boiling water. If citrate of lime is the end product desired, filter it, dry it thoroughly, and pack in waterproof packages.

Preparation of citric acid.—If citric acid is the end product desired, thoroughly mix the calcium citrate with water, in the proportion of 1 to 10 parts, and add an equivalent part of sulphuric acid. Separate the calcium sulphate from the dilute citric acid solution by filtration. Evaporate the filtrate in vacuo, and allow it to crystallize. Redissolve the first crystals, which usually are not of commercial grade, filter them through boneblack, and recrystallize. Mother liquors may be returned to be worked over again with a fresh batch of juice, or they can be repurified by recrystallization.

The main problem in the manufacture of citric acid is to secure a satisfactory container for evaporating the dilute citric acid solution. Wood is the most satisfactory material wherever it can be used. Enamel lined vacuum pans or pans constructed of monel metal are most favored by those who are manufacturing citric acid on a large scale.

CANDIED CITRUS PEEL.

Candied grapefruit peel makes an excellent center for chocolates and also serves as a substitute for citron in baking. Candied orange peel, while less like a confection, has sufficient merit to make it satisfactory for many purposes. It may be mixed with icings for cakes or with dough for cookies; it may also replace shredded coconut in homemade candies and fresh orange peel in marmalade. Many firms now use similar products instead of citron in making mincemeat.

Very superior candied peel has been obtained by using the following recipes.

CANDIED GRAPEFRUIT PEEL.

Preparation of the peel.—Wash the fruit and remove the peel, leaving as little of the white material attached to the fruit as possible. The peel can be more readily detached if the fruit is dipped in boiling water for a few minutes. If peel from fruit from which the juice has been pressed is to be used, the segment walls can be cleaned away with a knife. Not all of the peel from this class of material can be saved, but usually enough is recovered to make it pay. Cut the peel into strips 2 inches long by ¼ inch wide, into disks ½ inch wide, or into squares of the same size.

Cooking the peel.—There are two methods of cooking the peel. In one method water alone is used; in the other a preliminary treatment with limewater is given. Under certain conditions the finished product has a slightly tough layer at the surface, the remnant of the outer surface of the original peel. This toughness can be overcome by using limewater, although as a rule results almost as good are obtained by using water alone. Only the clear limewater should be used for this purpose, never milk of lime. Limewater contains only a few tenths of 1 per cent of lime in solution and will not injure the peel. Place the prepared peel in a kettle and cover it either with a mixture consisting of 2 parts of water and 1 part of clear limewater or with water alone. Cover and boil for half an hour. Pour off the liquid; again cover with water and boil for half an hour. Do not use limewater after the first cooking. Repeat the boiling, with fresh water each time, until a piece of the peel when removed and cooled has about the bitter taste that is desired in the finished product. The final product will be a little less bitter than the peel at this stage, as some of the bitterness disappears on further cooking. Usually three treatments are sufficient when a rather bitter flavor is desired. Five or six treatments produce a mild-flavored peel; more than that number give a product without much grapefruit flavor. When the desired flavor is reached, pour off the water and drain the peel; the excess of water can be removed by gentle pressure.

Candying the peel.—Prepare a sirup, using equal parts of granulated sugar[1] and water, and cover the peel with it. Boil very slowly for an hour or so, and allow the peel to remain in the sirup overnight, or longer if convenient. Finally, boil again until the sirup becomes thick, stopping the cooking at the usual end point for jelly making; that is, when the substance flakes or sheets from the spoon or the temperature on a candy thermometer is about 219° or 220° F. The peel is satisfactory even if cooking is stopped before it reaches this point; overcooking tends to make the peel hard. While hot, drain the sirup from the peel as completely as possible, shaking repeatedly to remove the last drops. Now roll the peel in powdered sugar, separating any pieces that stick together. Cool and allow to remain in the air for several days to dry out.

Storing the peel.—Place the dry peel in air-tight jars or cans, where it will keep for months.

CANDIED ORANGE PEEL.

The method used for grapefruit peel, with slight modifications, can be used for orange peel.

Preparation of the peel.—Wash the fruit, remove the peel, and cut into thin strips, about 1 inch long.

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[1] A better keeping and softer product is obtained by using one of the commercial invert sugars instead of cane sugar.

Cooking the peel.—Cover the peel with water and boil it for an hour, being careful to renew the water so that all of the peel remains covered. Pour off the water and repeat this operation at least once. The peel should be tender before the treatment with boiling water is stopped. Lacking the bitter taste of grapefruit, two treatments are usually enough.

Candying the peel.—Drain the tender peel, cover it with a 50 per cent sugar sirup, and cook it as directed for grapefruit. After the sirup is drained from it, roll the peel in powdered sugar, and expose it to the air until dry.

Storing the peel.—Store the dry peel in air-tight cans or jars.

MARMALADES.

There are almost as many ways to make marmalades as there are manufacturers of the product. The following directions, if carefully followed, will give excellent products.

CLEAR ORANGE MARMALADE.

Wash and pare the fruit.

Preparation of the peel.—Separate from one-fourth to one-half of the peel, choosing that free from blemishes. Cut this peel into very thin slices, cover with water, and cook until tender, changing the water at least twice during the cooking. When large quantities are being prepared, the method used for candied peel can be employed, stopping the process after finishing the cooking, but leaving the peel in the sirup until ready for use. The sirup can then be drained off and the peel added to the marmalade just before it is removed from the kettle.

Preparation of the juice.—Cut the peeled fruit into small pieces, cover in a kettle with twice its weight of water, and cook until the pieces are thoroughly disintegrated. If a highly colored and heavily jellying product is desired, part of the discarded peel can be cooked with the pulp. At this point make tests for acidity and pectin. From one-half to seven-tenths of 1 per cent of acid should be present, and about one-half of 1 per cent of pectin. If either be deficient, it should be made up by the addition of lemon juice for acidity and of peel for pectin. Throw the cooked pulp on a coarse filter cloth and press the moisture from it. Stir 5 pounds of thoroughly washed kieselguhr per 100 gallons of liquid into the filtrate, which is permitted to settle and finally filtered through cloth. A rack and plate press can be used for this operation.

Cooking the marmalade.—To this clear stock add a pound of sugar for each pound of fruit taken, together with the cooked peel. If candied peel is used, it need not be added until just before the batch is taken from the kettle; in fact, if desired, the peel can be placed in the containers and the finished jelly poured upon it. Evaporate the stock as rapidly as possible to the jellying point, usually about 220° F. It is best not to depend entirely upon the boiling point, however, as heavy pectin jellies will set with a lower sugar content than those containing smaller amounts.

Placing the marmalade in containers.—Pour the marmalade into hot glasses and, if necessary, stir the peel again before the jelly sets. Allow the glasses to cool and cover them with paraffin.

ORANGE MARMALADE (THREE-DAY METHOD).[2]

Wash the fruit and cut it very thin through pulp and rind, discarding all the seeds. Weigh the fruit and to each part add 3 parts of water. Let stand overnight. Next day boil for 30 minutes. Let it stand for 24 hours. At the end of this period measure or weigh the fruit. For each pound or portion of fruit juice add 1 pound or portion of sugar. Bring to a boil and cook until it reaches the jellying point, stirring to keep it from burning. Place it in glasses or jars while still hot, allow it to cool, and then cover the containers with paraffin.

SWEET ORANGE OR GRAPEFRUIT MARMALADE.[2]

Wash and peel the fruit. Weigh the peel and discard one-fourth of it, noting the weight of the edible portion plus the remaining peel.

Preparation of the peel.—Place the peel in water, boil for 5 minutes, and pour this water off. Cover the peel again with water and allow it to simmer over the fire until tender. Then pour off the water and add cold water to harden the peel. Next cut it into as thin slices as possible.

Preparation of the juice.—Place the peeled oranges or grapefruit in a kettle, add twice their amount of water, and boil until the pulp has disintegrated. Strain through a muslin or cheesecloth bag.

Cooking the marmalade.—Add to the juice 1½ pounds of sugar for each pound of peeled fruit plus shredded peel. Boil until the jellying point is reached.

Placing the marmalade in containers.—Pour the finished product into glasses or jars as directed for clear orange marmalade.

BITTER ORANGE MARMALADE.[2]

Wash and peel the fruit. Weigh the peel and discard one-fourth of it.

Preparation of the peel.—Cut the peel into as thin slices as possible; place it in a kettle with four times its weight of water; boil for 10 minutes; and drain free from water. Repeat this process three times.

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[2] Method devised in Carbohydrate Laboratory, Bureau of Chemistry.

Preparation of the juice.—After the peel has been removed, weigh the fruit and cut it into small pieces. Place it in a kettle and for each pound of orange add 2 pounds of water; boil until it thoroughly disintegrates. Pour the mass into a flannel jelly bag and press until no more juice can be extracted. Drain this juice again through a clean flannel jelly bag without pressing, or treat it with kieselguhr as directed on page 10.

Cooking the marmalade.—Pour this juice into a kettle. Add the peel and bring to a boil. Add 1½ pounds of sugar for each pound of fruit taken and continue the boiling until the jelly stage has been reached. This is indicated by the flaking or sheeting from the spoon.

Placing the marmalade in containers.—Pour the finished product into glasses or jars as directed on page 11.

JELLIES.[2]

BITTER ORANGE JELLY.

Bitter orange jelly is made by preparing the juice as directed for bitter orange marmalade. No peel is used in the jelly. For each pound of fruit taken 1 pound of sugar is added. This is boiled until it has reached the jellying point.

GRAPEFRUIT JELLY.

Grapefruit jelly is made by following the directions for making bitter orange jelly, with the exception that for each pound of fruit taken ¾ pound of sugar is added.

MINT AND ORANGE PECTIN JELLY.

Preparation of orange pectin.—Grate or scrape the yellow from the peel of 5 oranges. Pass ¼ pound of the white portion through a food chopper. For each ¼ pound of the peel add ¼ pound of water. Add the juice from half a lemon, mix thoroughly, and allow it to stand for 4 or 5 hours. At the end of this time add 1½ pounds of water, boil for 10 minutes, and allow to stand overnight. Next morning boil for 5 minutes and allow to cool. Place in a flannel jelly bag and press to remove the juice. Drain the juice through a clean flannel jelly bag.

Preparation of the jelly.—Pour 1 pound of orange pectin into a kettle, heat to boiling, and add 1 pound of sugar. Continue the boiling until the jellying stage is reached, which is indicated by the flaking or sheeting from the spoon, or by a temperature of 220° F. At this point add a small amount of green vegetable coloring matter and 2 drops of oil of peppermint. Stir thoroughly and pour while hot into clean, sterilized jelly glasses. After a few moments the scum which rises to the top may be easily removed with a spoon. When the jelly is cold, pour hot paraffin over it, and store.

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[2] Method devised in Carbohydrate Laboratory, Bureau of Chemistry.

ORANGE BUTTER.

The following recipe makes a product similar in many ways to apple butter. It spreads better than most marmalades or jellies, and is not so sweet. It is especially popular with children.

Preparation of the fruit.—Wash the fruit, carefully removing the stems, seeds, and blemish spots. Then cut it into slices or small pieces, cover with water, and cook until the peel is tender, which usually takes two or three hours.

Cooking the butter.—Add granulated sugar, either beet or cane, using only one-half the weight of the fruit taken, i. e., for each pound of fruit cooked ½ pound of sugar is added. Cook the mixture rapidly, with constant stirring, until a small sample, when cooled, has the desired consistency. It is best to cook beyond the jelly point. Cooking to 225° to 227° F. has given the best results in the laboratory.

As soon as it is sufficiently cool, pass it through a food grinder until all lumps are reduced.

A satisfactory product may also be made by adding 15 per cent of pineapple pulp to this material.

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